LLNL
Environmental Restoration Division (ERD)
Standard Operating Procedure (SOP)

ERD SOP 1.18: Deployment, Retrieval, Sampling, and Maintenance of Instrumented Membrane Technology (IMT) Borehole-Liner Systems

REVISION: 1 ENVIRONMENTAL RESTORATION DIVISION CONTROLLED COPY # THIS IS A RED STAMP ERD	**AUTHOR(S):** **Stanley A. Martins** **REVIEWERS:** **D. Bishop and M. Ridley**
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1.0 PURPOSE

This document describes the procedures used to deploy, retrieve, sample and maintain Instrumented Membrane Technology (IMT) borehole liner systems. These systems are used to keep uncased boreholes from collapsing, to deploy a variety of sensors that monitor sub-surface conditions and to sample the vadose zone and/or the water table.

2.0 APPLICABILITY

These systems are used to deploy sensors or sampling devices in soils where these devices are to be retrieved or renewed on a continuing bases, or where the system design is too complex to be deployed economically with other more permanent methods.

3.2 Martins, S. A., G. L. McQueen, R. E. Martinelli and M. C. Jovanovich (1992), *Factors Affecting Trichloroethylene (TCE) Recovery from SEAMIST Pads*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-JR-110604abs).

3.3 Mallon, B. S. A. Martins, W. Lowry, and C. Cremer (1992), *SEAMIST^{TM} Soil Sampling for Tritiated Water: First Years' Results*, Lawrence Livermore National Laboratory, Livermore , Calif. (UCRL-JR-109015).

4.0 DEFINITIONS

See SOP Glossary.

5.0 RESPONSIBILITIES

5.1 Division Leader

The Division Leader’s responsibility is to ensure that all activities performed by ERD at the Livermore Site and Site 300 are performed safely and comply with all pertinent regulations and procedures, and provide the necessary equipment and resources to accomplish the tasks described in this procedure.

5.2 Data Management Team (DMT)

The DMT’s responsibilities are to receive and process data according to applicable procedures and assist the Task Leader (TL) to develop sampling plans and sampling location IDs.

5.3 Task Leader (TL)

The TL’s responsibilities are to write the sampling plan, oversee the field team, deliver all data to the DMT, review the data collected, and prepare any final reports.

5.4 Field Team

The field team is responsible for assembling and testing supplies and equipment prior to work in the field. The field team is responsible for field recordkeeping and for collecting all samples according to the sampling plan and this SOP. The field team may make changes to the sampling plan in the field if required by logistics or terrain when authorized by the TL.

5.5 Site Safety Officer (SSO)

The SSO’s responsibility is to ensure the safety of ERD’s ongoing operations and facilities and of any work performed.

5.6 Technical Release Representative (TRR)

The TRR is responsible for the acquisition and administration of blanket contract releases for the procurement of goods and services. The TRR has the authority to obligate LLNL for payment of goods and services, delegated by the LLNL Business Manager through the Procurement Department.

6.0 PROCEDURES

There are five distinct activities associated with the use of IMT borehole liners. These activities are performed at different times in the life cycle of each installation. The first involves site selection, borehole construction, and membrane specification and procurement. An instrumentation and/or sampling plan must be devised prior to deployment so that all necessary equipment and supplies may be ordered. When the borehole is ready and each membrane has been instrumented, the IMT borehole liner must be deployed. Attachment A illustrates a typical deployment. Once in place, data acquisition and/or sampling from the IMT membranes may begin. The last activity is the retrieval of an IMT membrane. Membranes are retrieved to collect samples, change the membranes instrumentation or to terminate the use of the IMT system at that location.

6.1 Office Preparation

Office preparations will vary with the IMT activity that is to be performed. The user should be aware that not all of the preparations listed below would be performed at any one time.

6.1.1 Prior to borehole construction, the TL should contact the TRR to arrange for IMT membrane procurement and/or construction. If the final specifications for membrane procurement depend on the geological characteristics of the borehole, a blank IMT membrane should be available prior to drilling so that the borehole can be kept open while waiting for the fully instrumented liner.

6.1.2 The TL should arrange for drilling and select the IMT borehole site.

6.1.3 If a new IMT membrane is to be acquired, use data from the borehole construction to finalize the procurement specification for the IMT membrane. Give these specifications to the TRR so that the order can be completed.

6.1.3.1 Order all requisite sensors, data loggers and sampling supplies that will be needed for deployment far enough in advance so that they will be available when needed.

6.1.3.2 All data logger programs to be used with these installations should be written and tested in the office or laboratory prior to field installation. Write a plan that lists all of the sensors to be used with the IMT membrane and describes their placement. This plan should also include the rate at which data are to be acquired from each sensor. If the data logger is to control some aspect of the IMT facility, these functions should be listed.

6.1.3.3 When data are to be acquired electronically from IMT installations, appropriate transducers must be selected. If the manufacturer supplies suitable calibration data with these transducers, these calibration values may be used to represent these electronic signals as appropriate engineering units. In other cases, each transducer must be calibrated to derive these calibration values before installation in the field. Once the calibration factors have been established, the user can choose to incorporate them into the data logger program or to apply them during post processing. The choice of when to convert the electronic signals to engineering units can effect the resolution of these data.

6.2 IMT Membrane Deployment

6.2.1 If the target borehole for this installation is new, acquire a four or five foot length PVC pipe with the same outer diameter (OD) as the borehole. This pipe acts as a header and an attachment point for the IMT membrane wellhead. It should be driven into the borehole with about 6 to 12 inches extending above the surface. Seal the annulus of the borehole around the header pipe with grout.

If you are changing the IMT membrane in an old borehole, remove the old liner as described in the membrane retrieval procedure. A successful installation requires an empty, uncased borehole.

6.2.2 There are two types of IMT deployment canisters. The first is the old SEAMIST type that is deployed vertically over the borehole (Attachment A). The second type is the FLUTe type that is deployed horizontally. Select the one appropriate for the site. Most new applications will require the FLUTe canister.

6.2.3 Each membrane is provided with a tether-rope that is attached to the distal end of the membrane. Connect this tether to the rope found in the deployment canister with a shackle or with tie-wraps. With one person feeding the membrane into the canister, turn the canister handle in a clockwise direction and feed the rope, then the membrane into the canister. When all of the membrane is in the canister, lock the IMT wellhead onto the canister. The FLUTe system uses cam-lock fittings for this purpose while the SEAMIST system uses a friction fit.

6.2.4 Maneuver the deployment canister into the vicinity of the borehole and insert the IMT wellhead into the header-pipe. Level the deployment canister to reduce the strain on the components. Install a pressure gauge and pressure relief valve in the wellhead. Insert a compressed air hose into the well head quick-disconnect. Pressures up to 5 psi may be used with the FLUTe system, but the older SEAMIST system should be limited to about 3 psi. Most of the pressure relief valves on IMT installations at LLNL are set at less than 2 psi.

6.2.5 Apply air pressure to the deployment canister through the wellhead. This will inflate the membrane and force it down the borehole as the membrane is unwound from deployment canister spindle. Be sure to restrain the deployment canister handle so that the system’s momentum will not force more tether and/or membrane down the borehole than can be installed at any given time.

When no more tether or membrane moves down the borehole and the canister pressure does not drop for several minutes, one can assume that the deployment is complete. Exceptions to these indicators include a mechanical snag in the tether rope or membrane that prevents further deployment or very tight soil formations that prevent the air below the membrane from escaping into the soils. Both types of deployment canisters have windows through which the operator can view the deployment. One way to remove uncertainty about the completion of deployment is to place a mark on the tether rope that is visible from the deployment canister window at a place were the deployment in known to be complete. When this mark comes into view, one knows that the deployment is finished. The viewing window can also be used to diagnose other problems such as tangled tether or snagged membrane.

6.2.6 Disconnect the deployment canister from the wellhead and connect the membrane's tether to the wellhead cap with a shackle or with tie-wraps. Disconnect the deployment canister rope from the membrane-tether and close the wellhead by installing the cap. Pressurize the wellhead with compressed air and check for leaks. Repair any leaks that are found.

6.2.7 Disconnect the deployment compressor line from the wellhead and attach the air supply line that will be used to maintain membrane pressure. Pressure regulators used on LLNL IMT systems are set between 0.5 psi and 1.6 psi and will open at their set point if over pressure occurs. Monitor membrane pressure for a day or two to insure that there are no leaks in the membrane for which the maintenance air supply cannot compensate. Air escaping the pressure relief valve is a good indication that the membrane is tight and does not leak excessively.

6.3 IMT Membrane Retrieval

6.3.1 Depressurize the IMT membrane by holding the pressure relief valve open and/or removing the air hose from its fitting.

6.3.2 When the pressure has been released in the membrane, remove the wellhead cap. Maneuver the deployment canister into the vicinity of the borehole. Connect the tether-rope of the membrane to the rope found in the deployment canister with a shackle or with tie-wraps.

6.3.3 Remove the wellhead cap from the tether and insert the deployment canister fitting into the wellhead. Level the deployment canister to reduce the strain on the components. Turn the canister handle in a clockwise direction so that the tether-rope and then the membrane will be wound up inside the canister.

6.3.4 When all of the membrane is in the canister, remove the wellhead from the header pipe.

6.3.5 The membrane may be removed form the deployment canister by disconnecting the wellhead from the canister and pulling the membrane out of the canister by hand. When the membrane is removed in this way, the inside of the membrane will be exposed to the air, protecting the side of the membrane exposed to the soil from contact with personnel or the environment.

If the deployment canister is pressurized through the port on the wellhead, the membrane will be everted with the soil side out. One would chose this method if one wishes to retrieve or install sorbent-pads, or if instruments connected to the outside of the membrane are to be repaired, replaced or removed.

6.4 Electronic Data Acquisition

6.4.1 All data loggers have a limited amount of data storage. On most data loggers, data are logged into a circular buffer where the oldest data are overwritten by the newest. To avoid the loss of data, provide a method (such as modem or radio) to automatically retrieve data at regular intervals, or set up a schedule to visit the data logger and down load data manually.

6.4.2 After data have been down loaded from the data logger, process these data so that they can be archived in ways that others can understand. This usually means that data recorded as millivolts (mV) or counts should be converted to the appropriate engineering units.

6.4.3 If these values are to be incorporated into the Data Management System, transfer these data to Data Management Team (DMT) at regular intervals.

6.4.4 Review the data regularly to insure that all sensors are giving reliable readings and that power to the data logger is sufficient for continued operation.

6.5 IMT Sampling

Most vapor sampling methods used at IMT installations are similar to those used with other types of borehole completions. Because some IMT installations are equipped with sorbent-pads, the user may wish to become familiar with the proper techniques to deploy and retrieve these pads.

All IMT systems equipped to sample from soils identify each sample location with a port or pad number. Each number is associated with a designated depth from the surface. Samples are labeled with unique identifiers that usually combine the sample location number with a borehole descriptor. Consult the DMT for proper sample names for each site. Vapor sampling IMT liners are described in Attachment B.

6.5.1 Vapor sampling for VOCs may include the use of Summa canisters, sorbent-tubes, Tedlar bags, or Organic Vapor Analyzer (OVA). Use the accepted method associated with these devices to acquire samples.

6.5.2 Because most of the tritium in the vadose zone of our soils is in the form of water vapor, these samples are usually acquired by pumping soil-gas through a cold trap where this water can be condensed and stored for laboratory analysis by scintillation counter. For details on this method, consult Martins (1992). (Reference 3.1 of this SOP).

6.5.3 Sorbent-pads from IMT membranes are used to collect soil pore-water samples. These pads can be weighed prior to deployment and again after they are retrieved. Subtracting the dry weight from the wet weight will give the net sample weight prior to analysis. Because some soil particles can adhere to these pads, it is recommended that the analytical laboratory dry each pad to obtain a third pad weight after analysis is complete. If the post-analytical weight is greater than the pre-deployment weight, the former should be used to calculate sample weight. Once sorbent-pads have been collected for analysis, they should be treated as soil samples for each analyte of interest. Because VOCs can be lost through volatilization, they must be handled quickly and carefully. For more details on the use of sorbent-pads for VOC analysis, consult Martins (1992). (Reference 3.2 of this SOP). Attachment C describes the sorbent-pad liners.

6.5.3.1 IMT sorbent-pads can be deployed in pouches on the outside of the membrane. Retrieve the membrane and remove the wellhead from the borehole. Pressurize the deployment-canister and evert the membrane horizontally over a clean surface. When the first pouch appears, carefully remove the pad and place the pad in a pre-weighed vessel (such as Zip-lock® plastic bag or soil-VOA) as quickly as possible. Repeat this process until all pads have been retrieved.

6.5.3.2 IMT sorbent-pads can be deployed as a tube wrapped around the entire circumference of the membrane. These pads are secured with either buttons, snaps, or ties to the membrane. To sample these pads, retrieve the membrane and remove the wellhead from the borehole. Pressurize the deployment-canister and evert the membrane horizontally over a clean surface. As the first pad emerges, carefully place a pre-weighed plastic bag over the part of the membrane containing the pad and continue to evert the membrane until the entire pad is exposed. Detach the pad from the membrane by manipulating the pad fasteners through the plastic bag. Remove the pad and bag from the membrane and seal the pad inside the bag as quickly as possible. Repeat this process until all pads have been retrieved.

6.5.3.3 With both methods, the operator should weigh the pads after sampling or instruct the analytical laboratory to do this so the net weight of the sample may be obtained.

6.6 IMT System Maintenance

Many of the components of these systems will require maintenance from time to time due to natural deterioration or accidental damage. The best way to determine when the system needs attention is to monitor it on a regular basis. When in the field, observe all visible components of the system. Review all data collected with these systems and look for any unexplained anomalies.

6.6.1 Low membrane pressure could be the result of loose connectors, faulty pressure hoses, problems with the air-supply system or holes in the membrane itself. If the problem occurs, you will need to check all of these possibilities.

6.6.2 Most of our IMT systems use Brailsford model TD-4A, 12 VDC diaphragm pumps to maintain membrane pressure. When these pumps fail, it is usually because the Teflon flapper valves get dirty. When this happens, one can disassemble the pump head and clean the valves. If the valves are damaged, replace the pump head or the entire pump. The next most frequent fault is a ruptured diaphragm. Installing a new diaphragm under the pump head should correct this problem. Replacement pumps or parts for these pumps are available from Brailsford & Co, Inc., Rey, NY.

6.6.3 Sealed lead-acid batteries power all IMT data loggers and most air pumps. Many of the batteries are charged with solar panels. Solar panels will become dirty over the summer months and should be cleaned before the shorter days and frequent overcast of the winter months reduce daylight to the point were the batteries cannot maintain their charge.

The lead-acid batteries have a finite lifetime and must be replaced after several years of use. When these batteries can no longer hold a normal voltage between charges, or charging the batteries becomes ineffective, it is time to replace these batteries. Marginal batteries should be replaced before winter.

6.6.4 Many sensors and gauges will function indefinitely without the need of repair, replacement, or recalibration. Others, such as gypsum blocks, have a finite lifetime and must be replaced at regular intervals. Study the data from these devices at regular intervals and look for suspicious results. Sometimes the only way to know when sensors need attention is to observe or test them.

6.7 IMT Vapor Extraction System

IMT borehole liner systems may be used to deploy rigid piping for either passive or active vapor extraction. These borehole liners are constructed specifically for this purpose and are deployed in a slightly different way from the normal liner.

A very bulky pad is attached to the outer side of the membrane, starting at the top of the extraction zone. The other end of the pad is terminated at the bottom of the liner with a 3” diameter threaded coupler. This threaded coupler is connected to the tether line by a threaded plug. When the membrane is half deployed, the plug and tether line are removed from the threaded coupler, and are replaced by Tremie pipe. Sections of pipe are added as the remainder of the membrane is deployed. The last section of Tremie pipe is sealed with a packing gland at the well head.

Once deployed, vapor from the soil surrounding the pad in the extraction zone is pulled through the pad into the Tremie pipe. This gas stream is then treaded at the surface as is appropriated for the analytes found in the gas stream.

6.7.1 Prepare the borehole with a grouted wellhead as described above. If the extraction zone is deeper than 30 to 40 feet, install a rigid support structure around the wellhead that can support the Tremie pipe after installation. An example of this type of support may be viewed in Attachment D.

6.7.2 Load the new-type deployment canister with the membrane as described above. Care must be taken when the 3” threaded coupler is first introduced into the deployment canister to avoid damage to the membrane, threaded coupler and canister. Attachment E shows the threaded coupler as it enters the deployment canister.

6.7.3 Deploy the membrane until the 3” threaded coupler is visible in the canister window. The membrane may stop feeding from the canister when the threaded coupler is at the wellhead. If this happens, remove the canister from the wellhead and feed the threaded coupler through by hand.

Once the 3” threaded coupler is at the wellhead, remove the plug from the top of the wellhead. If the canister is still connected to the wellhead, remove the canister. Hold the end of the membrane and remove the plug connected to the tether line to the 3” threaded coupler. Push this threaded coupler into the wellhead and orient it toward the top of the wellhead where the wellhead plug was removed.

Place the threaded retention ring and rubber packing gland on the first section of Tremie pipe with the thread on each pointing in the same direction. Push the threaded end of the Tremie pipe into the top of the wellhead and screw it into the 3” threaded coupler that is connected to the end of the membrane. Replace the “dust” cover in the wellhead where the canister was connected.

Disconnect the compressed air line from the wellhead and replace it with a camlock fitting connected to a shop-vacuum. The shop-vacuum is needed to supply enough air to deploy the membrane and to replace air that is lost past the Tremie pipe.

Loosely thread the retention-ring into the wellhead around the Tremie pipe. Turn on the shop-vacuum and start lowering the Tremie pipe down the borehole. The weight of the Tremie pipe will increase as more sections of pipe are added. After about 30 to 40 feet, the pipe becomes difficult to hold by hand. At this point restrain the pipe using the same techniques described in ERD SOP-1.3, “Drilling” and SOP-1.4, “Monitor Well Installation.” Remember that the wellhead conductor casing goes down less than 6 feet and is not designed to hold the weight of many sections of Tremie pipe. When installation is complete, the bulk of this weight must be born by the supporting structure described in Section 6.7.1.

When one section less that half of the total length of Tremie pipe has been installed, replace the shop-vacuum with the compressed air line. Bring the membrane pressure up to at least 2 psi. If the membrane pressure is too low at this point, the membrane will not deploy correctly.

When installation is complete, remove the camlock attached to the compressed air source and connect the air-maintenance air-line to the wellhead. Tighten the retention ring around the Tremie pipe at the well head and bring the membrane pressure up to 1 or 2 psi. Check for leaks.

6.7.4 Once the membrane installation is complete, and the Tremie pipe is secured to the supporting structure, vapor extraction may commence.

7.0 QUALITY ASSURANCE RECORDS

7.1 Chain-of-Custody Form

7.2 Document Control Logbook

7.3 Sampling and Analysis Plans

8.0 ATTACHMENTS

Attachment A—IMT Deployment Schematic Using an SEA Type Deployment Canister

Attachment B—IMT Vapor/Water Sampling Schematic

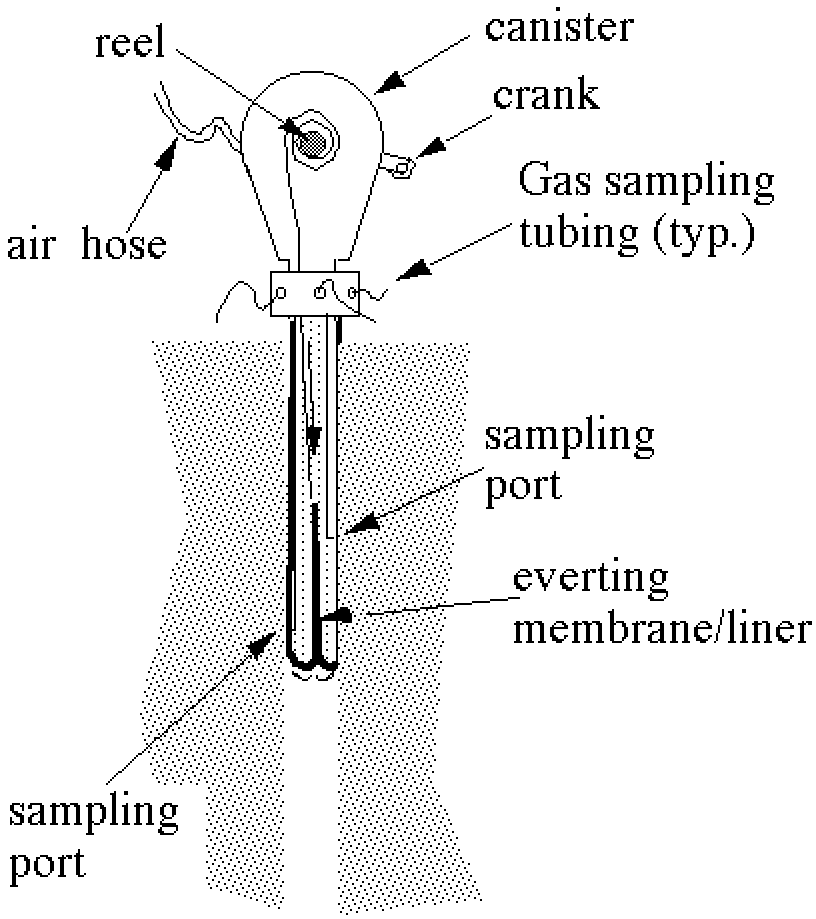
Attachment C—IMT Sorbent-Pad Sampling Schematic

Attachment D—IMT Vapor Extraction Borehole Liner System with Support Structure

Attachment E—Loading IMT vapor extraction borehole liner into deployment canister.

Attachment A

IMT Deployment Schematic Using a SEA Type Deployment Canister

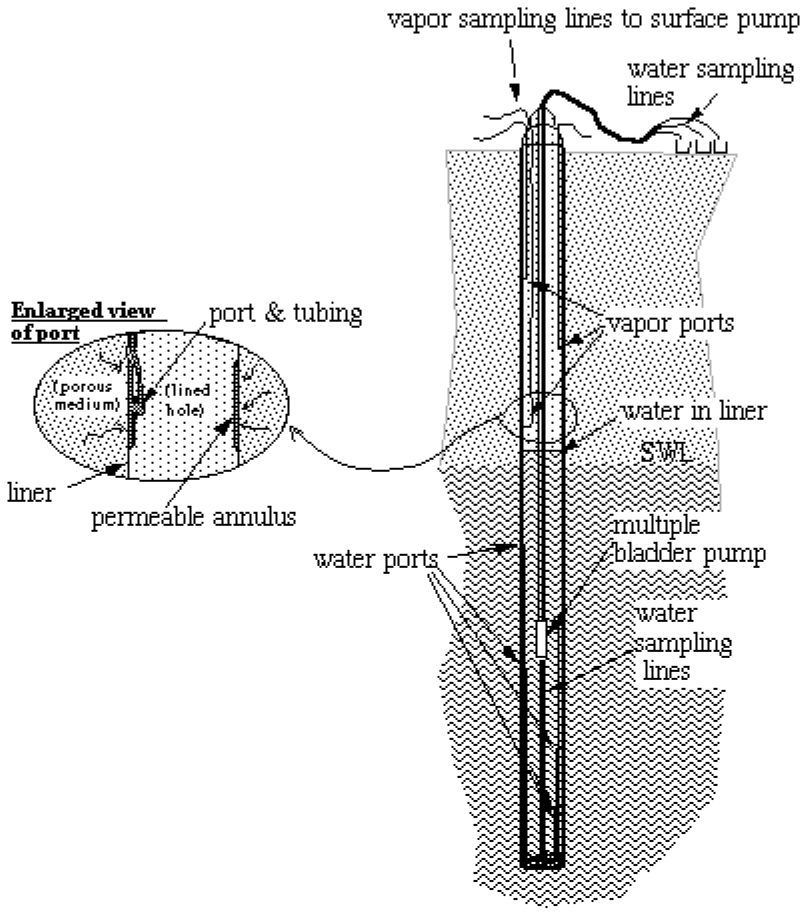


Attachment A. IMT deployment schematic using a SEA type deployment canister*.

* Illustrations courtesy of FLUTe, Santa Fe NM.

Attachment B

IMT Vapor/Water Sampling Schematic

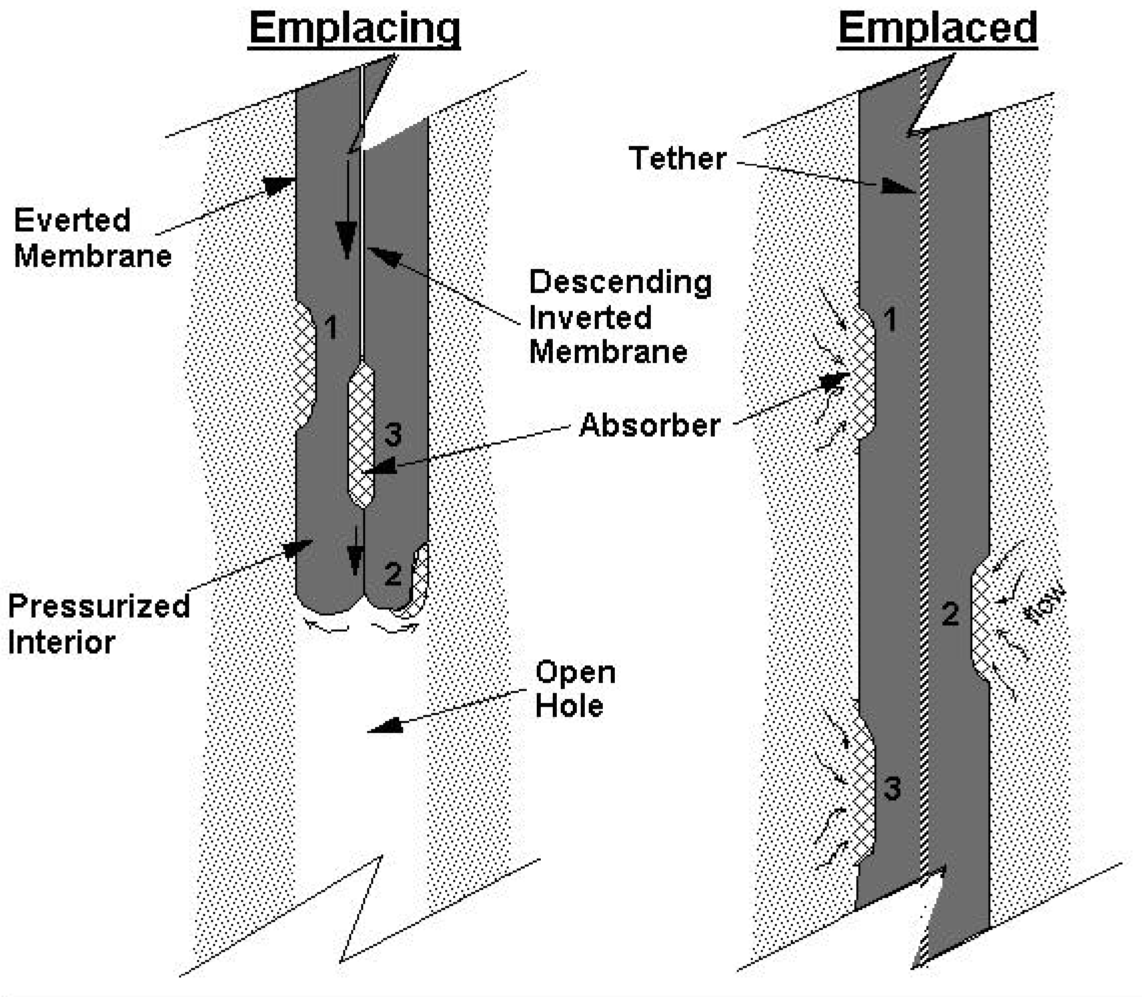


Attachment B. IMT vapor/water sampling schematic*.

* Illustrations courtesy of FLUTe, Santa Fe NM.

Attachment C

IMT Sorbent-Pad Sampling Schematic



Attachment C. IMT sorbent-pad sampling schematic*.

*** Illustrations courtesy of FLUTe, Santa Fe NM.**

Attachment D

Attachment D: IMT Vapor Extraction Borehole Liner System with Support Structure

Attachment D. IMT vapor extraction borehole liner system with support structure.

Attachment E

Attachment E: Loading IMT Vapor Extraction Borehole Liner Into Deployment Canister

Attachment E: Loading IMT vapor extraction borehole liner into deployment canister.